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Cosmogenic nuclide intercalibration at the Bishop Tuff, CA, USA

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The accuracy of surface exposure dating with cosmogenic nuclides and related research, such as erosion rate studies, is limited by the precision of the currently used production rates. As part of CRONUS-EU, a European research effort trying to refine this dating method by various interdisciplinary approaches, we aim to determine relative production rates of several cosmogenic nuclides in different minerals.

The Bishop Tuff in eastern California is a welded ignimbrite deposit that erupted 760 $\pm$ 2 ka ago from the Long Valley Caldera [1]. It has experienced erosion, so absolute calibration is not possible. However, surface samples from the Bishop Tuff can be used for relative intercalibration of the production rates of cosmogenic nuclides (^{3}He, ^{21}Ne, ^{10}Be, ^{26}Al) in minerals available in individual samples of the ignimbrite unit, such as quartz (qz), clino- and orthopyroxene (cpx, opx), titanomagnetite and sanidine.

Of the twenty samples analysed for cosmogenic ^{21}Ne in quartz, four have also been studied for ^{3}He and ^{21}Ne in coexisting opx and cpx, and one additionally for ^{3}He in titanomagnetite. The ^{10}Be concentration in quartz has been determined in ten of these samples so far.

It is not common that qz and px exist together in one rock, making this a valuable opportunity to directly determine and compare the production rate ratios of ^{3}He and ^{21}Ne in cpx and opx to ^{21}Ne in coexisting quartz. These values can be compared with production ratios derived from model calculations based on major element composition [e.g. 2,3]. We found production ratios of 1.23$\pm$0.13 and 1.45$\pm$0.23 for ^{21}Ne(cpx)/^{21}Ne(qz) and ^{21}Ne(opx)/^{21}Ne(qz), respectively, in one sample, which are in excellent agreement with values calculated according to [2] (1.23 and 1.50, respectively) and [3] (1.24 and 1.45, respectively). For the other samples similar production ratios have been found, but the elemental compositions have not been determined yet.

Unfortunately, the concentrations of cosmogenic ^{3}He cannot currently be resolved due to possible contributions of both magmatic and nucleogenic ^{3}He. We aim to quantify the non-cosmogenic component by analysing totally shielded samples.

Despite erosion, relative production ratios of ^{10}Be and ^{21}Ne in quartz can still be approximated, using the measured concentrations of the nuclides and a factor that depends on the erosion rate and rock properties. Analysed quartz samples yield preliminary values of $\sim$0.23 – 0.27 for P_{10}/P_{21}, related to a ^{10}Be half life of 1.51 Ma. We expect to compare production rates of ^{21}Ne and ^{26}Al in the same manner in the next months.

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